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REMOTE SENSING OF OCEAN CURRENTS

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16. Abstract

Fourteen field experiments in support of the NOAA investigation of ocean color boundary determination using ERTS data have been conducted since June 1972. The boundary between coastal waters and the Loop Current has been detected by ERTS as a result of sea-state changes as well as color differences. Computer enhancement of MSS data are revealing many features not shown in the NDPF product. Analysis of the 24 channel MSS data shows that a thermal IR channel is required on an ERTS MSS to distinguish between atmospheric and sea state effects. Cloud cover analysis suggests the need for daily coverage of this type sensor for routinely useful oceanographic applications.

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July:	3400
August:	2800
September:	3000
Supplies:	5500
Travel:	900
Support:	2400
TOTAL	$ 22000

PREFACE

The objective of this investigation is to locate ocean current boundaries by sensing the color change associated with the cyclonic edge of the zone of maximum horizontal velocity shear. The test site is the eastern Gulf of Mexico where the strongly baroclinic flow from the Yucatan Straits forms into the Loop Current. The research is using ERTS' data in the investigation of ocean color sensing.

A time series of the location of the Loop Current was begun in August 1972. For every other transit of ERTS (i.e., 36 days) the current is located by ship. These data are being used to provide surface measurements in support of the spacecraft observations and to obtain the first time history of the circulation in the eastern Gulf of Mexico.

Further time histories of the variables which allow the use of ocean color as a current detection phenomenon are being made. These research cruises were conducted for over one year in order to understand the seasonal variability associated with the circulation and detection of the circulation's surface indicators.

INTRODUCTION

This interim report covers the third six months of the ocean current detection project using ERTS data. Five field experiments have been conducted in support of the work, all of which are part of a continuing time history of the Loop Current. ERTS images which appear to show the current boundary do so because of either changes in sea-state or ocean color.

FIELD DATA COLLECTION

Ship-satellite experiments were performed in June, July, August and September. A time-series of the Loop Current was obtained by occupying the suborbital track of ERTS that passes into the Yucatan Straits every 36 days. The research vessel was on the suborbital track on the day of satellite transit collecting continuous chlorophyll-a, volume scattering, and radiometric temperature (in conjunction with the NOAA-2 IR sensors); hourly (15 km interval) expendable bathythermograph, surface bucket temperature and salinity samples were obtained. During daylight, spectra of upwelling and downwelling radiance (400-800 nm) were measured with 1/4 meter Ebert scanning spectroradiometer, weather permitting. Upon reaching the Yucatan Straits a temperature/salinity/depth (STD) transect of nine stations were made in order to determine the geostrophic current and transport fields. After the STD transect, the surface boundary of the Loop Current was tracked using the same measurements outlined for the subsatellite track. A second STD transect of the Florida Straits from Key West to Havana was made in order to determine the discharge from the basin.

AIRCRAFT EXPERIMENT

Continued study of the 24 channel Bendix MSS data across the Loop Current front has shown that reflection patterns in the sea surface, presumably caused by turbulent wind stress in the atmospheric boundary layer, are seen at all but the longest ($>8\,\mu m$) infrared wavelengths. Physically this is a statement that the longer wavelengths have higher emissivities (and have lower reflectances), a well established fact. If these data are extrapolated to spacecraft observations one would be unable to tell if these shorter wavelength pattern observations were atmospheric (clouds, fog, etc.) or oceanic. The long wavelength infrared observations can resolve this question because if the patterns were atmospheric they would appear in these data. Therefore, as a recommendation to future ERTS sensors where water studies are to be made a 10.5-12.5 μm channel is required to separate sea-state induced reflection patterns from thermally coupled

boundary regions, and indeed to add a degree-of-freedom to the analysis.

SHIP EXPERIMENT

The last cruise of the ERTS ground truth series was taken in September. All in all, 15 cruises were made on the project, 3 were ship/aircraft experiments, and 12 were the time-series of the Loop Current every 36 days from August 1972 to September 1973. The September 1973 cruise report is attached; other reports for this six month period are attached to the bimonthly reports.

Between August and September a large anticyclonic eddy detached from the main current. The main flow was found at its lowest (latitude) since last March and seems to confirm the hypothesis of an annual growth (spring) eddy formation (summer) and collapse (fall-winter). The growth to the northern Gulf coast was later this year than "usual" as remarked on by the fishermen in that area noting that the larger animals did not come until August this year (as compared to May, the "usual" period). This was of course, caused by the flow patterns in the Loop Current.

Analysis of the ship data for transports through the straits, annual chlorophyll-a variations, scattering and other optical property variations, and thermal variations will require a significant time block in order to properly correlate the variability to be anticipated. Data collection in the New York Bight as part of this laboratory's participation in MESA has begun. Those data will help to quantify our tentative conclusions in the Bight and provide the ground truth for the time-series being made in this area using ERTS data.

ERTS DATA

The results of many of the experiments using JPL's VICAR system have been discussed in bimonthly reports and were presented as a paper at the Annual Meeting of the ASP-ACSM, Orlando, Florida, in October 1973. The paper is being written at this time for formal publication, however, several computer experiments need to be done before the work is completed. Many of these results were presented and discussed with personnel of NOAA/NESS and the NASA ERTS review panel in late October 1973.

In summary, we found that most of the ocean information is lost in the NDPF product because the average scene radiance is half an order of magnitude higher than the ocean scene. Computer enhancement brings out features that are one DN different on the average, and these are the levels across boundary layers in many cases. Several techniques such as ratioing were tried but the straight enhancement by contrast stretching seems to provide the most satisfactory results at this writing.

Several more important spectra have been obtained during a joint NOAA-NASA ocean color experiment. These data include harbor water, dredging sites, sewer-outfalls, and algae rich areas. Data processing has begun to study ratios (etc.) with these data. This begins a cataloguing of spectra which hopefully will include a wide range of water types and quality.

PROGRAM FOR NEXT REPORTING INTERVAL

Processing the physical, biological, and spectral data from the cruises will consume the bulk of the next reporting period. Continued efforts will be made with computer enhancement of selected scenes and with the time-series in the New York Bight. Continued theoretical calculations by H. R. Gordon (co-investigator) are being made concerning the nature of photon transmission using the Monte Carlo code.

CONCLUSIONS

The time-series in the Gulf of Mexico has added significantly to our understanding of the variability in this region. The current's boundary is well correlated with local fisheries and a combination of ship and satellite data is being used to explain the Florida east coast red tide of November 1972. Computer processing is required to extract current boundaries in the deep sea and is extremely important in coastal areas. Analysis of 24 channel MSS data dictate the need for a 11.5 μm infrared channel in a future ERTS for meaningful water resources analysis.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORIES
PHYSICAL OCEANOGRAPHY LABORATORY
NASA/GSFC

CRUISE REPORT
R/V VIRGINIA KEY

17-23 September
1973

I. OBJECTIVES

The purpose of this cruise was to continue a time series of the location of the Loop Current as part of AOML's project with the Earth Resources Technology Satellite (ERTS) and the NOAA-2 Meteorological Satellite. The research is intended to obtain baseline information on the spectroradiometric properties of the ocean's surface useful for remote sensing and the detection of that information at orbital altitudes.

II. SCHEDULE

Date	Time	Activity
September	DST	
17	0800	Depart Miami
18	1100	Commenced STD transect of Florida Straits
20	0000	Commence STD transect of Yucatan Straits
	2000	Commence tracking current
21	1000	Satellite transit
22	0200	Complete survey
23	2200	Arrive Miami

III. STATION POSITIONS

The northern limit STD transect of the Florida Straits was at the

100-fathom curve south of Marquesa Key Light and terminated 12 n. mi. north of Havana Cuba. The station locations were:

24°21'N	82-09W	Station 1
24°11'N	82-11W	2
24°05'N	82-16W	3
23°55'N	82-19W	4
23°44'N	82-23W	5
23°34'N	82-28W	6
23°21'N	82-29W	7

The station locations for the Yucatan Straits STD transect were:

21°50'N	85-10'W	8
21°48'N	85-20'W	9
21°47'N	85-31'W	10
21°45'N	85-40'W	11
21°42'N	85-53'W	12
21°40'N	86-03'W	13
21°38'N	86-12'W	14
21°33'N	86-22'W	15
21°31'N	86-33'W	16

The easternmost station was 12 n. mi. west of Cabo San Antonio the westernmost station was 12 n. mi. east of Isla Contoy.

The cruise from Isla Contoy to Dry Tortugas was a saw-toothed path, which crossed the surface boundary layer zone of the current.

IV. PERSONNEL

Michael Ednoff, Chief Scientist	FSU
John Hazelworth	NOAA/AOML
Gary Dingle	NOAA/AOML

V. DESCRIPTION OF OPERATIONS

Data collection commenced with an STD transect of the Florida Straits. Continuous flow measurements of chlorophyll-a and continuous radiometric sea surface temperature were recorded on a dual channel recorder. While on the track, hourly XBTs, surface bucket temperature, surface salinity, and measurements of scattering ratios were taken.

Spectra of upwelling and downwelling visible radiation were not observed. Loran A fixes were made at one hour intervals and at major course, and/or speed changes. One liter samples were filtered for a

spectrophotometer calibration of chlorophyll-a every six hours and at major changes in the fluorescence, and for biological samples.

The final cruise of the time series observed that an anticyclonic eddy detached between August and September. The eddy was confirmed by a cruise of the R/V BOWERS just prior to the R/V VIRGINIA KEY's cruise. The main current was found at its southernmost position in six months and served to confirm the notion that an annual cycle for the flow exists.

VI. LOGS

Chief Scientist Log
Deck Log
Track Chart
Loran Log (C&GS 722)
Hydrographic Station
Bathythermograph Log

Submitted by: George A. Maul
November 5, 1973